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TECHNICAL REPORT

Characterization of the Radiological Environment at J-Village during Operation Tomodachi

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Prepared by:

Operation Tomodachi Registry,
Dose Assessment and Recording Working Group

For:

Assistant Secretary of Defense for Health Affairs

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14. ABSTRACT

This report presents a characterization of the radiological environment during Operation Tomodachi at J-Village, a facility located 12.5 mi (20 km) south of the Tokyo Electric Power Company's (TEPCO) Fukushima Daiichi Nuclear Power Station (FDNPS). The accident at FDNPS following the earthquake and tsunami on March 11, 2011 in Japan resulted in releases of radioactive materials into the environment. TEPCO used J-Village as a staging area for emergency response and cleanup. Individuals affiliated with the U.S. Department of Defense visited J-Village during Operation Tomodachi. The data presented in this report include personal dosimetry and internal monitoring results for DOD-affiliated individuals who visited J-Village, as well as external exposure rate measurements and the results of air, soil, and vegetation sampling at or nearby the site. Guidelines for use of the data in future radiation dose assessments are also provided.

15. SUBJECT TERMS
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UNIT CONVERSION TABLE
U.S. customary units to and from international units of measurement*

U.S. Customary Units	Multiply by → / ← Divide by†		International Units
Length/Area/Volume			
inch (in)	2.54	$\times 10^{-2}$	meter (m)
foot (ft)	3.048	$\times 10^{-1}$	meter (m)
mile (mi, international)	1.609 344	$\times 10^{3}$	meter (m)
micron (μ)	1	$\times 10^{-6}$	meter (m)
angstrom (Å)	1	$\times 10^{-10}$	meter (m)
barn (b)	1	$\times 10^{-28}$	square meter (m^2)
gallon (gal, U.S. liquid)	3.785 412	$\times 10^{-3}$	cubic meter (m^3)
Mass/Density/Force			
pound (lb)	4.535 924	$\times 10^{-1}$	kilogram (kg)
atomic mass unit (AMU)	1.660 539	$\times 10^{-27}$	kilogram (kg)
pound-mass per cubic foot (lb ft^{-3})	1.601 846	$\times 10^{1}$	kilogram per cubic meter (kg m^{-3})
pound-mass-square foot (lb ft^2)	4.214 011	$\times 10^{-2}$	kilogram-square meter (kg m^2)
pound-force (lbf avoirdupois)	4.448 222		newton (N)
pound-force inch (lbf in)	1.129 848	$\times 10^{-1}$	newton-meter (N m)
pound-force per inch (lbf in^{-1})	1.751 268	$\times 10^{2}$	newton per meter (N m^{-1})
Energy/Power			
electronvolt (eV)	1.602 177	$\times 10^{-19}$	joule (J)
erg	1	$\times 10^{-7}$	joule (J)
kilotons (kT) (TNT equivalent)	4.184	$\times 10^{12}$	joule (J)
British thermal unit (Btu) (thermochemical)	1.054 350	$\times 10^{3}$	joule (J)
foot-pound-force (ft lbf)	1.355 818		joule (J)
calorie (cal) (thermochemical)	4.184		joule (J)
Pressure			
kip per square inch (ksi)	6.894 757	$\times 10^{6}$	pascal (Pa)
atmosphere (atm)	1.013 250	$\times 10^{5}$	pascal (Pa)
bar	1	$\times 10^{5}$	pascal (Pa)
torr (Torr)	1.333 224	$\times 10^{2}$	pascal (Pa)
pound-force per square inch (psi)	6.894 757	$\times 10^{3}$	pascal (Pa)
Angle/Temperature/Time			
hour (h)	3.6	$\times 10^{3}$	second (s)
degree of arc (^{o})	1.745 329	$\times 10^{-2}$	radian (rad)
degree Fahrenheit (^{o}F)	[T(^{o}F) − 32]/1.8		degree Celsius (^{o}C)
degree Fahrenheit (^{o}F)	[T(^{o}F) + 459.67]/1.8		kelvin (K)
Radiation`			
curie (Ci) (activity of radionuclides)	3.7	$\times 10^{10}$	per second (s^{-1}‡)
roentgen (R) (air exposure)	2.579 760	$\times 10^{-4}$	coulomb per kilogram (C kg^{-1})
absorbed dose (rad)	1	$\times 10^{-2}$	joule per kilogram (J kg^{-1}**)
equivalent dose (rem)	1	$\times 10^{-2}$	joule per kilogram (J kg^{-1}††)

*Specific details regarding the implementation of SI units may be viewed at http://www.bipm.org/en/si/.
†Multiply U.S. customary unit by factor to get international unit. Divide international unit by factor to get U.S. customary unit.
‡The special name for the SI unit of activity of a radionuclide is the becquerel (Bq). (1 Bq = 1 s^{-1}).
**The special name for the SI unit of absorbed dose is the gray (Gy). (1 Gy = 1 J kg^{-1}).
††The special name for the SI unit of equivalent and effective dose is the sievert (Sv). (1 Sv = 1 J kg^{-1}).

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Section 1.

Introduction

1.1 Overview

An earthquake and subsequent tsunami in Japan on March 11, 2011[1] led to releases of radioactive materials into the environment from the Tokyo Electric Power Company (TEPCO) Fukushima Daiichi Nuclear Power Station (FDNPS). In response to this disaster, the United States (U.S.) Department of Defense (DOD) conducted Operation Tomodachi, a humanitarian assistance and disaster relief operation in support of the Government of Japan (GOJ) following the earthquake and tsunami. This report describes the radiological environment at J-Village, a facility located 20 km (12.5 mi) south of the FDNPS that approximately 20 individuals who were affiliated with the U.S. DOD visited during Operation Tomodachi.

1.2 Background Information

On March 11, 2011, a magnitude 9.0 earthquake occurred with an epicenter off the east coast of Japan. Less than an hour after the earthquake, a massive tsunami inundated the FDNPS site and caused significant damage to the facilities and subsequent loss of electrical power. Eventually, damage to the reactor fuel occurred followed by releases of radioactive materials into the environment. In its first report to the International Atomic Energy Agency, the GOJ estimated the activities[2] of the radioactive materials released into the atmosphere as 1.5×10^{17} Bq (4.0×10^{6} Ci) of I-131 and 1.2×10^{16} Bq (3.2×10^{5} Ci) of Cs-137 during the period March 11 to April 5, 2011 (GOJ, 2011a). Additional estimates and other details of FDNPS releases are available and are consistent with the initial GOJ estimated releases (e.g., GOJ, 2011b; Cassata et al., 2012; WHO, 2012).

About 70,000 DOD-affiliated individuals were working and/or living at locations in and around Japan and were potentially exposed to the released radioactive materials. This includes about 53,000 individuals who were at shore-based locations, primarily large naval or air bases, and about 17,000 individuals who were aboard ships. The dose assessments for the majority of these DOD-affiliated persons are documented in Cassata et al. (2012) for the shore-based individuals and in Marro et al. (2013) for the ship-based individuals.

This report was produced by the Operation Tomodachi Dose Assessment and Recording Working Group (DARWG), the DOD working group that is responsible for conducting radiation

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[1] Japan Standard Time (JST), 0000-2400, is used throughout this report, unless otherwise noted. JST is 9 hours ahead of Coordinated Universal Time (UTC). DOD's use of UTC is traditionally noted by the "Zulu (Z)" designation, e.g., 1630Z.

[2] In this report, radiological quantities are expressed using either the International System of Units (SI) or U.S. customary units. Measurement results are expressed in the unit reported in source documents with the equivalent value in the other system expressed in parentheses. DOD more commonly uses traditional units for reporting radiation doses; therefore, in this report, doses are reported in units or subunits of rem with the SI equivalent values in parentheses.

dose assessments in support of the establishment of the Operation Tomodachi Registry[3]. This Registry will include the names and radiation exposure estimates of nearly 70,000 DOD-affiliated individuals who were on or near the mainland of Japan during the period from March 12, 2011 to May 11, 2011. This report complements a series of reports prepared by DARWG that address radiation internal monitoring; radiation doses for fetuses, embryos, and nursing infants; and probabilistic uncertainty analysis for selected shore locations. The DARWG reports, either completed or in progress, are as follows:

- Radiation Dose Assessments for Shore-Based Individuals in Operation Tomodachi, Revision 1 [DTRA-TR-12-001 (R1)]
- Probabilistic Analysis of Radiation Doses for Shore-Based Individuals in Operation Tomodachi (DTRA-TR-12-002)
- Radiation Internal Monitoring by In Vivo Scanning in Operation Tomodachi (DTRA-TR-12-004)
- Radiation Dose Assessments for the Embryo, Fetus, and Nursing Infant during Operation Tomodachi (DTRA-TR-12-017)
- Radiation Doses for Fleet and Air Individuals in Operation Tomodachi (DTRA-TR-12-041)
- Comparison of Radiation Dose Studies of the 2011 Fukushima Nuclear Accident Prepared by the World Health Organization and the U.S. Department of Defense (DTRA-TR-12-048)

1.3 Purpose and Scope of Report

The primary purpose of this report is to summarize available radiological data and related information for J-Village pertaining to the period March 12–May 11, 2011. This period represents the time during which DARWG evaluations indicated the largest potential for exposure to DOD-affiliated individuals existed (Cassata et al., 2012). A second purpose of this report is to provide guidelines for use of the data in future radiation dose assessments for individuals who visited J-Village and were exposed to higher levels of radiation than at their home basing location. The radiological data available for J-Village include personal dosimetry results and internal monitoring results for individuals who visited J-Village, and environmental monitoring data from locations at and near J-Village.

The scope of this report is to discuss the data pertaining to those potential exposure pathways that are applicable to individuals who visited J-Village during the period March 12–May 11, 2011. Calculated radiation doses are not included in this report because DOD-affiliated personnel visiting J-Village were issued external radiation dosimeters (USPACOM, 2011), and the individuals were present at J-Village for very short time periods. If calculated doses are needed in the future for individuals who visited J-Village, guidelines for identifying details of their activities relating to their exposure scenarios are included in this report.

[3] The registry web page can be accessed at: https://registry.csd.disa.mil/

Section 2.

The J-Village Complex

2.1 General Description of J-Village

J-Village is a soccer training center and sports complex located approximately 20 km (12.5 mi) south of FDNPS near the town of Naraha in Fukushima Prefecture. The site consists of a complex of training fields, dormitories, medical facilities, cafeterias and gymnasiums, that was built for Japan's co-hosting of the World Cup in 2002 (Natakoji, 2011). The J-Village complex serves as the Japan Football Association's National Training Center. An aerial view of the J-Village soccer fields and some of the facilities is provided in Figure 1.

Following the FDNPS accident, J-Village was used as a command center by TEPCO, its contracted workers, GOJ officials, and Japanese Self-Defense Forces (JSDF) involved in the response efforts. The J-Village facilities were used to stage emergency response personnel and to plan operations at the FDNPS. J-Village was also used as a decontamination and support area for emergency response personnel working at the FDNPS. (Belson, 2011)

Figure 1. Aerial view of the J-Village complex (looking south)

2.2 Visits by DOD-affiliated Individuals to J-Village

During Operation Tomodachi, military commands within the Pacific/Japan area, including U.S. Pacific Command (USPACOM), U.S. Forces Japan (USFJ), and military service component commands, such as the Commander, U.S. Pacific Fleet, provided specific guidance on and directed a number of actions to protect the health and safety of the DOD-affiliated population on mainland Japan. These actions included issuing health protection guidance to control radiation exposure, and establishing criteria for entry into restricted zones around the FDNPS. Because of its location relative to the FDNPS, J-Village was within a restricted access zone initially defined as "the area within 25 nautical miles of the Fukushima Reactor Plant" or "the area in which general area radiation levels are in excess of 0.01 rem h^{-1}" (USFJ, 2011a). This was later revised to "the area within 40 km (25 mi) of the Fukushima Daiichi Reactor Plant, or… areas in which general radiation levels are in excess of 0.01 rem h^{-1}" (USFJ, 2011b). As of March 16, 2011, all DOD individuals authorized for travel to J-Village were required to have "personal protective equipment" and "individual radiological monitoring equipment," among other requirements (USPACOM, 2011). DOD-affiliated individuals visiting J-Village used personal protective equipment as necessary, they were issued external radiation dosimeters, and they were afforded the opportunity for internal monitoring (Appendix A of this report; USPACOM, 2011).

DOD-affiliated personnel traveled to J-Village to meet with individuals from the JSDF and TEPCO, and to "determine radiological measurement capabilities and obtain readings, as practicable" (USFJ, 2011d). Consequently, DOD-affiliated individuals were occasionally present at J-Village for short durations during the period March 12–May 11, 2011. None of these individuals are known to have been housed at J-Village.

As discussed later in this report, approximately 20 DOD-affiliated individuals who visited J-Village during Operation Tomodachi have been identified by name. The visits by these individuals involved stay times ranging from about 2 to 4 hours. The visits to J-Village for which documentation is available consisted of the following activities:

- Arriving via truck or helicopter, using one of the soccer fields as a landing zone;
- Attending indoor meetings at J-Village facilities;
- Conducting environmental sampling and measurements; and
- Performing flight crew ground duties associated with trips to J-Village.

The DOD-affiliated individuals who have been confirmed as having been at J-Village during Operation Tomodachi were either flight crew, distinguished visitors (DVs) and staff, or members of DOD-affiliated radiological response teams. The response teams consisted of members of the Defense Threat Reduction Agency's (DTRA) Liaison Office (LNO) and Consequence Management Advisory Team (CMAT), and the U.S. Air Force Radiation Assessment Team (AFRAT). Members of these teams were among the first to visit J-Village following the FDNPS accident because of their responsibilities to provide advice, information, and equipment regarding hazard assessment and consequence management following radiological incidents (AFRAT, 2012; DTRA, 2012).

Based on available documentation, the earliest date that any DOD-affiliated individual visited J-Village is March 24, 2011. On this date, logistical support and supplies were to be available to support the movement by truck of a four-person team from Yokota Air Base to J-Village (USFJ, 2011c). The team consisted of individuals from DTRA and USFJ. Based on personal communication with one of the individuals on this team, this trip and return to Yokota Air Base were completed in a single day (Wright, 2012).

On March 25, 2011, several DVs and an AFRAT member were transported via helicopter to J-Village. A total of nine individuals were on this mission, six of whom were DOD-affiliated. Based on Yokota Air Base departure and return times, the approximate time at J-Village for these individuals was from 1400 to 1530. Using information in the AFRAT Surveillance Team Report (see Appendix A) and known sampling locations (see Section 3.4), it is presumed that the helicopter used the soccer field enclosed within the oval in the center of Figure 1 as a landing area. The helicopter crew and AFRAT member remained onboard or near the helicopter on the artificial turf soccer field while the DVs were presumably inside one or more of the J-Village buildings. The AFRAT member also conducted dose rate measurements and collected air samples as described in Section 3.4.

On March 27, 2011, several DVs and an AFRAT member traveled to J-Village via helicopter (Appendix A). Seven or eight of the ten individuals on this trip were DOD-affiliated, and two were individuals from the U.S. Nuclear Regulatory Commission. One of the DOD-affiliated individuals was a DV who was also on the March 25 trip discussed above. The helicopter arrived at J-Village at 1000 and departed from J-Village at 1330. Similar to the March 25 mission, the helicopter crew and AFRAT member remained near the helicopter and the artificial turf soccer field while the DVs were presumably inside one or more of the J-Village buildings. During this visit, the AFRAT team member made dose rate measurements and collected soil and vegetation samples near the soccer fields (see Section 3.4).

The three visits discussed above, involving a total of 16 or 17 different DOD-affiliated individuals, are the only visits to J-Village during Operation Tomodachi for which documentation was available. If additional information becomes available in the future regarding other trips to J-Village involving DOD-affiliated individuals, it could be used to supplement the information in this report.

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Section 3.

Radiological Data

3.1 Overview

The FDNPS releases of radioactive materials to the environment were potential sources of exposure to individuals who visited J-Village. These releases resulted in external exposures primarily as a result of radioactive materials transported to the area of the J-Village and deposited on the ground or structures. Radioactive materials in the air and soil at J-Village may have resulted in internal radiation doses if materials were taken into the body by inhalation or incidental ingestion of soil and dust.

3.2 Dosimetry Data

A limited amount of dosimetry data is available for DOD-affiliated individuals related to visits to J-Village. This includes dosimetry results for individuals who visited J-Village over the period of Operation Tomodachi.

3.2.1. Dosimetry for J-Village Visits

The only available dosimetry results that are specific to J-Village visits are electronic personal dosimeter (EPD) results for individuals on the March 25 and 27, 2011 visits (USAFCRD, 2011). EPD results for individuals on the March 25, 2011 trip to J-Village are all less than 1 mrem (10 μSv), as shown in Table 1. The mean dose for the AFRAT and helicopter crew members during this mission is 0.64 mrem (6.4 μSv), and the mean dose for the five DVs on this mission is 0.24 mrem (2.4 μSv). The higher mean dose for AFRAT and helicopter crew members is likely due to their location outdoors (near the helicopter), while the DVs were presumably indoors for part of the mission ground time (Appendix A).

The available EPD readings for the trip to J-Village on March 27, 2011 are shown in Table 2. The highest EPD reading for this trip is 1.3 mrem (13 μSv). The mean dose for the helicopter crew members on this mission is 0.66 mrem (6.6 μSv). On this trip the AFRAT member spent time outside the helicopter collecting soil and vegetation samples, which probably resulted in the higher EPD result for that individual as compared to those for the helicopter crew members (Appendix A).

3.2.2. Other Relevant Dosimetry Results

Thermoluminescent dosimeter (TLD) results are available for some of the DTRA LNO/CMAT individuals and other DTRA-affiliated individuals who may have visited J-Village (Hinton, 2012). Only one of these results is for an individual who is confirmed to have visited J-Village as a member of the March 24, 2011 trip. The period of issue for this TLD result is March 23–April 2, 2011, and the reported dose is 0.00 rem (0.0 mSv). The period of issue includes the presumed date of that individual's trip to J-Village. Assuming that this individual

was wearing this TLD during the entire period of issue, the result reflects that no detectable dose was accrued while at J-Village.

Table 1. EPD results for March 25, 2011 trip to J-Village

Individual	Individual Doses [mrem (μSv)]*	Average Dose Rate [mrem h^{-1} (μSv h^{-1})]†
AFRAT member	0.62 (6.2)	0.41 (4.1)
Helicopter crew member #1	0.64 (6.4)	0.43 (4.3)
Helicopter crew member #2	0.57 (5.7)	0.38 (3.8)
Helicopter crew member #3	0.74 (7.4)	0.49 (4.9)
DV #1	0.24 (2.4)	0.16 (1.6)
DV #2	0.23 (2.3)	0.15 (1.5)
DV #3‡	0.24 (2.4)	0.16 (1.6)
DV #4‡	0.23 (2.3)	0.15 (1.5)
DV #5‡	0.25 (2.5)	0.17 (1.7)

*Deep dose as measured by an EPD.
†The average dose rates were calculated by assuming the individual doses were accrued during 1.5 hours while on the ground at J-Village.
‡DV#3, DV#4, and DV#5 were not DOD-affiliated individuals.

Table 2. EPD results for March 27, 2011 trip to J-Village

Individual	Dose [mrem (μSv)]*	Average Dose Rate [mrem h^{-1} (μSv h^{-1})]†
AFRAT member	1.3 (13)	0.37 (3.7)
Helicopter crew member #1	0.54 (5.4)	0.15 (1.5)
Helicopter crew member #2	0.58 (5.8)	0.17 (1.7)
Helicopter crew member #3	0.87 (8.7)	0.25 (2.5)

*Deep dose as measured by EPD.
†The average dose rates were calculated by assuming the individual doses were accrued during 3.5 hours while on the ground at J-Village.

3.3 Internal Monitoring

Internal monitoring (IM) includes both IM (*in vivo*) scans and urine bioassay (*in vitro*) monitoring of individuals who visited J-Village.

3.3.1. Internal Monitoring (*In Vivo*) Scans

The available IM scan data consist of the results of external thyroid and chest measurements made using portable and/or fixed instrumentation as described in Cassata et al. (2013). IM scan results have been located for 12 DOD-affiliated individuals known to have been

at J-Village on one or both of the trips on March 25 and March 27, 2011. For the twelve monitored individuals, all calculated internal doses are 0 rem because measured thyroid and chest activities for all radionuclides other than background constituents were below the minimum detectable activity (MDA) for the method used (Cassata et al., 2013; Williams, 2013). A summary description of the types of IM scans conducted on these individuals is shown in Table 3.

Table 3. Type of IM scans conducted for individuals who visited J-Village

Dates and Individuals[*] on J-Village Trips (2011)	Type of IM Scan[†]
March 25 trip:	
AFRAT member	Portable
Helicopter crew member #1	Portable
Helicopter crew member #2	Portable
Helicopter crew member #3	Both[‡]
DV #1	Fixed
DV #2	Portable
March 27 trip:	
AFRAT member	Portable
Helicopter crew member #1	Portable
Helicopter crew member #2	Portable
Helicopter crew member #3	Portable
DV #1 (same as DV#1 on March 25 trip)	Fixed
DV #2	Fixed
DV #3	Fixed

[*]Individuals on March 25 and March 27 trips are the same as those in Table 1 and Table 2 (if listed).
[†]Portable = E-600/SPA-3, Fixed = ACCUSCAN or FASTSCAN, Both = Individual had measurements on both portable and fixed instrumentation (Cassata et al., 2013).
[‡]This individual had portable IM scan results indicating a total cesium activity greater than the MDA, but confirmatory measurements using fixed instrumentation resulted in total cesium activity less than the MDA.

3.3.2. Urine Bioassay (*In Vitro*) Monitoring

The *in vitro* monitoring data consist of urine bioassay results that are available for two DOD-affiliated individuals who visited J-Village (USAFSAM, 2011a, 2011b). The available urine bioassay results are reported as activity concentrations (e.g., pCi L^{-1}); calculated internal doses are not available. Documentation is not currently available concerning information such as date of intake, and conditions/procedures of collection. In addition, inconsistent reporting of measurement uncertainties, critical levels, and/or MDA values in the results makes interpretation difficult. Because of the difficulty in interpreting the significance of these *in vitro* monitoring results, they are considered unreliable and are not reported here.

3.4 Environmental Monitoring

The available environmental monitoring data for J-Village for the period March 11–May 12, 2011 are presented in this section. These data include the results of measurements of dose rates and activity concentrations from air, soil and vegetation sampling. The available environmental monitoring data are from the Japanese Ministry of Education, Culture, Sports, Science & Technology (MEXT) and AFRAT. Further information on MEXT data can be found in Cassata et al. (2012) and MEXT (2013).

3.4.1. External Dose Rate Monitoring near J-Village from MEXT

A set of external dose rate measurements was obtained from MEXT and the U.S. National Nuclear Security Administration (NNSA) for a monitoring site located approximately 0.5 km (0.3 mi) southeast of the J-Village main building entrance at latitude 37.241536 and longitude 141.005831[4]. This location is indicated as "MEXT dose rate monitoring location" in Figure 2. This site is the location closest to J-Village for which near-daily measurements were available over most of the period of Operation Tomodachi.

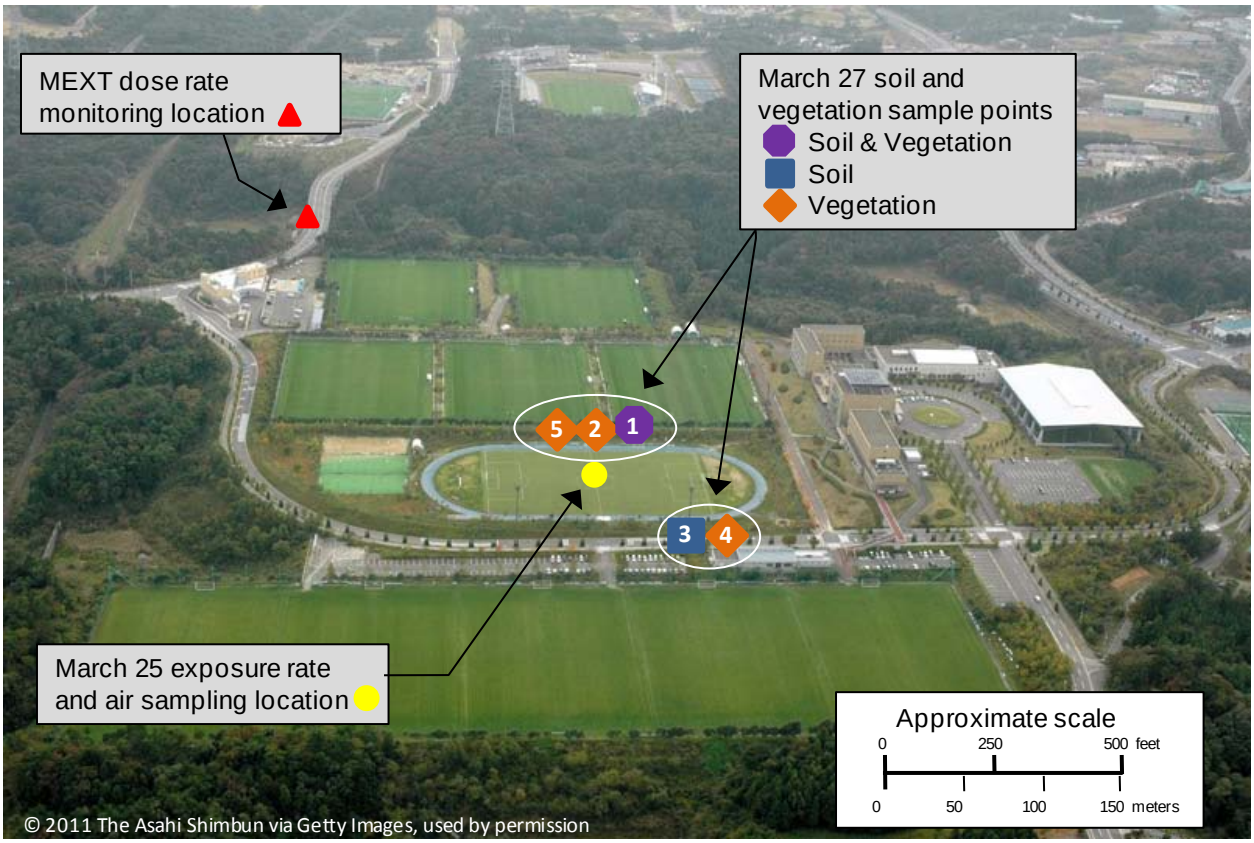

Figure 2. Monitoring and sampling locations at and near J-Village (looking south)

[4] Latitude and longitude are specified in this report using decimal degrees. See Appendix B for equivalent latitude and longitude expressed in degree-minute-second format.

The set of external dose rates comprises 144 dose rate measurements taken near J-Village using an ionization chamber survey meter or a thallium-activated, sodium-iodide scintillation detector over the period March 17–June 1, 2011. The measurements at this location were taken by TEPCO and other Japanese sources such as Kyushu Electric Power Company, and were collected by MEXT (MEXT, 2013). The NNSA subsequently obtained the data from MEXT and compiled them into a single data set within their Japan Response Data Repository. (NNSA, 2012). A plot of the measurements for the station near J-Village during the Operation Tomodachi period is shown in Figure 3, and the data are listed in Appendix C.

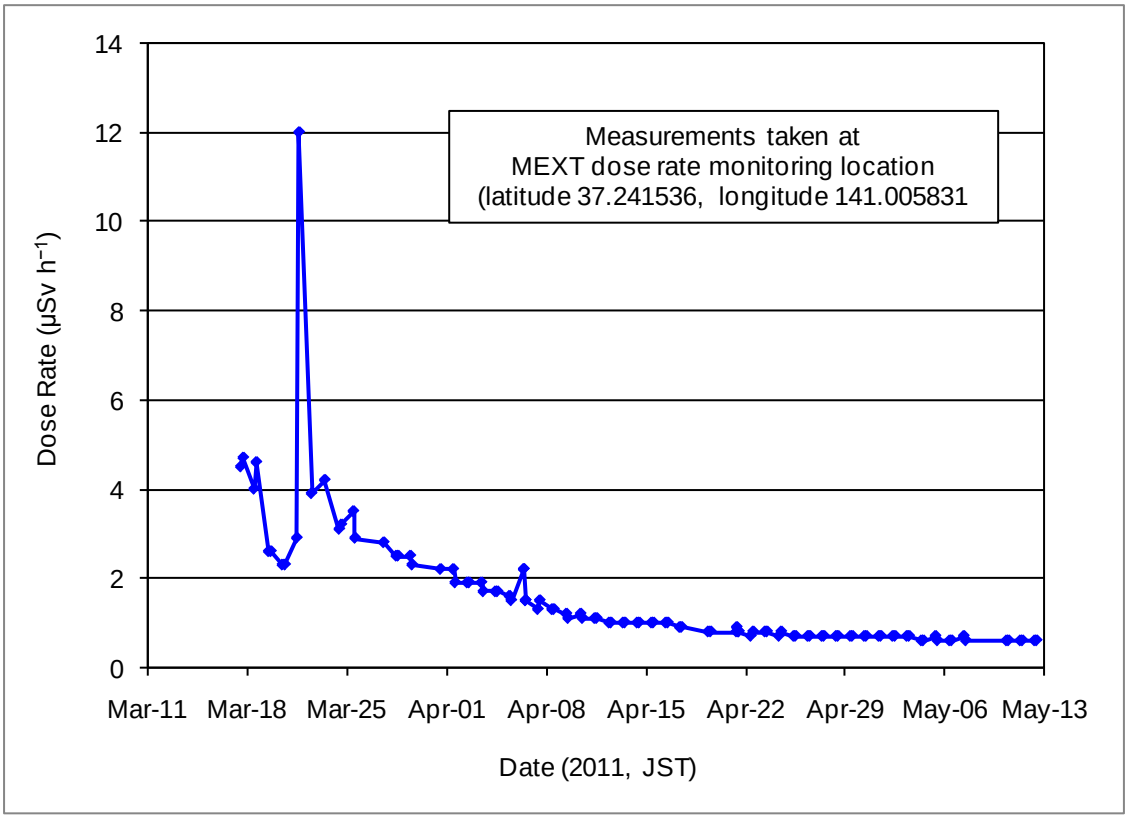

Figure 3. MEXT/NNSA external radiation measurements taken near J-Village during Operation Tomodachi

The background radiation exposure rate at J-Village before the accident is not available. However, two measurements taken by portable instrumentation at 1600 on March 10, 2011—one approximately 1.3 km (0.8 mi) south of J-Village and the second about 1.6 km (1 mi) northwest of J-Village (NNSA, 2012)—indicate a pre-accident background exposure rate of 0.004 mR h^{-1} (0.04 µSv h^{-1}) in the area. The measurements taken near J-Village were originally reported in the unit of equivalent dose. It is assumed that the dose rates were due primarily to gamma radiation and can also be expressed in the unit of exposure as reported by NNSA.

3.4.2. Exposure Rate Monitoring at J-Village by DOD

AFRAT team members made exposure rate measurements on March 25 and March 27, 2011 while accompanying DVs to J-Village. The measurements were made using a Victoreen/Fluke 451P pressurized ionization chamber [see Appendix A of Cassata et al. (2012) for instrument descriptions]. The March 25 measurements were made at latitude 37.2455 and longitude 141.0045 as indicated by "March 25 exposure rate and air sampling location" in Figure 2. The specific location of the March 27 exposure rate measurement was not recorded; however, based on the soil and vegetation measurement locations (see Section 3.4.4), it is assumed that the March 25 and March 27 exposure rate measurement locations were the same. The measurement outside the helicopter on March 25 and the single recorded measurement for March 27 were each characterized by AFRAT as the "highest dose rate" measurement taken by the AFRAT member while on the ground at J-Village during that day's mission. The exposure rate measurements are given in Table 4. (AFRAT, 2011; Appendix A of this report)

Table 4. AFRAT external radiation measurements at J-Village

Date (2011)	Measurement [mR h^{-1} (µSv h^{-1})]*	Location
March 25	0.46 (4.6)	outside helicopter†
March 25	0.38 (3.8)	inside helicopter†
March 27	0.7 (7)	unknown‡

*The measured exposure rates are assumed to be equivalent to dose rates.

†The helicopter was located at latitude 37.2455 and longitude 141.0045 while on the ground at J-Village (inside the oval shown on Figure 2).

‡It is assumed that this measurement was taken at latitude 37.2455 and longitude 141.0045, based on the locations of other measurements.

3.4.3. Air Monitoring

AFRAT surveillance personnel took two air samples at J-Village on March 25, 2011. The air samples were taken at latitude 37.2455 and longitude 141.0045 as indicated by "March 25 exposure rate and air sampling location" in Figure 2. These samples were taken using a low-volume air pump provided by a Department of Energy team. The AFRAT Sampling Mission Log Workbook (AFRAT, 2011) indicates that Sample 20079 was taken "inside the helicopter with the doors closed 95% of the time," and the AFRAT Surveillance Team Report (Appendix A) indicates that it was taken over a period of 1.25 hours. Sample 20080 was initiated immediately after the end of the first sample; it is not known whether it was taken inside or outside the helicopter. AFRAT personnel analyzed the air samples and the results are provided in Table 5.

The Cs-137 concentration reported for Sample 20080 in Table 5 is suspicious and may not be a valid result. The value is reported here because it has been reported in some data sheets reviewed for this report as the upper value of the 95% confidence interval. However, the value was reported in the USFJ Master Raw Air data file as the Cs-137 MDA (USFJ, 2011e). The USFJ data file included a note indicating that such a reported value "was actually below the MDA, but the measurement is listed as equivalent to the MDA." More fundamental to the validity of the value are the observations that it is approximately twice as high as the mean or

upper (mean + 2 standard deviations) Cs-137 concentration reported for Sample 20079, and also that it is approximately 50 percent higher than the upper Cs-134 value reported for Sample 20080. Based on air sample analyses for other locations (Cassata et al., 2012), and independent analysis of FDNPS fallout deposition (Ishii et al., 2013), the Cs-134 and Cs-137 activity concentrations at J-Village in all media are expected to be within 20 percent of one another.

Table 5. Results of AFRAT air sampling at J-Village on March 25, 2011

Isotope	Activity Concentration[*,†]			
	Sample 20079[‡]		Sample 20080[§]	
	pCi L^{-1}	Bq L^{-1}	pCi L^{-1}	Bq L^{-1}
I-131	0.050 ± 0.004	0.0018 ± 0.00015	0.066 ± 0.023	0.0024 ± 0.0009
Cs-134	0.010 ± 0.002	0.00037 ± 0.00007	0.0084 ± 0.0021	0.00031 ± 0.00008
Cs-137	0.0080 ± 0.002	0.00030 ± 0.00007	0.0166[**]	0.0006[**]

[*]Both samples were taken at latitude 37.2455 and longitude 141.0045 as indicated by "March 25 exposure rate and air sampling location" in Figure 2.

[†]Uncertainties equal ±2 standard deviations, and are assumed to represent laboratory measurement uncertainty.

[‡]Results for Sample 20079 were obtained by analyzing a 47-mm filter.

[§]Results for Sample 20080 were obtained by analyzing a TC-12 triethylene di-amine impregnated carbon cartridge.

[**]This value was reported both as the MDA and as the upper value of the 95% confidence level.

Additional information on the AFRAT air samples collected on March 25, 2011 is listed below (AFRAT, 2011).

- AFRAT Sample 20079:
  - The sample was collected starting at 1421;
  - The sample point given in the logbook is "Soccer Field;"
  - The sample was analyzed at 0200 on March 30, 2011.
- AFRAT Sample 20080:
  - The sample was collected starting at 1536;
  - The sample point given in the logbook is "Middle of soccer field, co-located log side J-ville Hospital [*sic*];"
  - The sample was analyzed at 1140 on March 29, 2011.
- Additional information for both samples:
  - The sample coordinates listed are 3714.73, 14100.27;
  - The sample purpose is "Used to determine exposures resulting from a specific incident;"
  - The POC/contact information is AFRAT.

3.4.4. Soil and Vegetation Monitoring

AFRAT team members took one soil sample and one vegetation sample on March 27, 2011 for which isotopic analysis results were available. The AFRAT Sampling Mission Log Workbook (AFRAT, 2011) indicates that the soil sample (Sample 20196) was collected at

latitude 37.245173 and longitude 141.00428 ("March 27 soil and vegetation sample point 1" in Figure 2). AFRAT personnel performed three isotopic analyses of the soil sample, on April 1, April 11, and April 15, 2011 (USFJ, 2011f). The results of the last analysis, which list measured activity concentrations that are higher than results of the two earlier analyses, are given in Table 6. The first analysis of the soil sample contained values for two radionuclides (Tc-99m and Xe-133) that were not reported in the subsequent analyses. For Tc-99m, values from the first analysis are listed in Table 6. Values for Xe-133 are not included in Table 6 because it is believed that this noble gas would not be present in a soil sample, and is an anomaly.

Table 6. Analysis results for AFRAT soil Sample 20196 at J-Village on March 27, 2011

Isotope	Activity Concentration[*,†]	
	(pCi g^{-1})	**(Bq g^{-1})**
Tc-99m[‡]	0.792–1.19	0.0293–0.0441
I-131	405–442	15.0–16.3
Te-132	48.5–68.3	1.79–2.53
Cs-134	21.1–22.7	0.782–0.838
Cs-136	2.42–2.96	0.0895–0.110
Cs-137	21.9–25.7	0.810–0.952
La-140	0.493–0.951	0.0182–0.0352

[*]Soil Sample 20196 was collected at latitude 37.245173 and longitude 141.00428 as indicated by "March 27 soil and vegetation sample point 1" in Figure 2

[†]Values listed were reported as the range of the 95% confidence interval for each isotope (lower value–upper value) and are assumed to represent analysis uncertainties (USFJ, 2011f).

[‡]Values for Tc-99m are from the first sample analysis.

Additional information on AFRAT soil Sample 20196 collected on March 27, 2011 is listed below (AFRAT, 2011):

- The sample was collected at 1100;
- The sample point given in the logbook is "J Village, Surf Soil/Sand;"
- The sample was initially analyzed at 1700 on April 1, 2011;
- The sample purpose is "Used to determine exposures resulting from a specific incident;" and
- The POC/contact information is AFRAT.

The AFRAT vegetation Sample 20387 was also collected on March 27, 2011 in the same area as soil Sample 20196 ("March 27 soil and vegetation sample point 1" in Figure 2). Results of the AFRAT vegetation sample analysis are shown in Table 7 (AFRAT, 2011; USFJ, 2011f). Additional information on this vegetation sample is as follows (AFRAT, 2011):

- The sample was collected at 1038;

- The sample point given in the logbook is "J Village, next to soccer field;"
- The sample was analyzed at 1005 on April 3, 2011;
- The sample purpose is "Used to determine exposures resulting from a specific incident;" and
- The POC/contact information is AFRAT.

Table 7. Analysis results for AFRAT vegetation Sample 20387 at J-Village on March 27, 2011

Isotope	Activity Concentration[*, †]	
	(pCi g^{-1})	(Bq g^{-1})
Rh-105	211–304	7.81–11.2
I-131	3864–4196	143–155
Te-132	484.7–587.3	17.9–21.7
Cs-134	321–342	11.9–12.7
Cs-136	35.2–38.0	1.30–1.41
Cs-137	321–395	11.9–14.6
La-140	7.52–8.78	0.278–0.325

[*]Vegetation Sample 20387 was collected at latitude 37.245173 and longitude 141.00428 as indicated by "March 27 soil and vegetation sample point 1" in Figure 2.

[†]Values listed were reported as the range of the 95% confidence interval for each isotope (lower value–upper value) and are assumed to represent analysis uncertainties (USFJ, 2011f).

Two additional soil samples, two vegetation samples, and one water sample were also obtained on March 27, 2011, and were given to the U.S. Nuclear Regulatory Commission for analysis. Results for these samples were not available (AFRAT, 2011).

In addition to the soil and vegetation samples that were analyzed isotopically, external measurements were made on soil and vegetation samples taken at five locations near the J-Village soccer fields (Figure 2) using a Bicron Analyst with a Pancake Geiger-Müller probe (Cassata et al., 2012). The surveys were made during the March 27 visit to J-Village, and the results are shown in Table 8. (AFRAT, 2011)

Table 8. Results of AFRAT soil and vegetation sample measurements on March 27, 2011

Sample Point*	Measurement Surface	Beta plus gamma counts per minute	Latitude	Longitude
1	Soil (top soil with vegetation)	31,000	37.245173	141.00428
3	Soil (loose dirt)	5,000	37.246067	141.004009
2	Vegetation (moss and grass)	15,000	37.245161	141.00447
4	Vegetation (leaves)	20,000	37.246105	141.003961
5	Vegetation (tall grass)	35,000	37.245089	141.004517

*See Figure 2.

Section 4.

Guidelines for Use of Radiological Information in Radiation Dose Assessments at J-Village

4.1 Overview

Guidelines are provided in this section for the use of radiological data and other information included in this report when performing individual radiation dose assessments for individuals who travelled to J-Village in the 60-day period following the FDNPS accident. According to procedures in place (JSFJ, 2011; USPACOM, 2011), DOD-affiliated individuals were required to obtain authorization from Commander, Joint Support Force to travel to J-Village and/or to conduct aerial monitoring survey flights in restricted-access zones. DOD-affiliated individuals traveling to J-Village were also required to wear individual radiological monitoring equipment such as TLDs or EPDs, and were to be monitored for internal contamination if any skin contamination was detected per the same procedures (JSFJ, 2011).

4.2 Collection of Individual Participation Information

When performing an individualized radiation dose assessment for radiation exposures at J-Village, information about the individual's activities at J-Village should be collected. This information would be obtained mainly from historical records and reports, including this report, and statements from the individual through verbal or written communication, such as a phone interview, questionnaire or both. The individual's relevant medical records and dosimetry records should be obtained and reviewed. Also, individuals should be invited to submit any documentation that contains information about their participation and activities performed in support of Operation Tomodachi. Based on a review of official records and information provided by the individual, any sources of additional relevant information that are identified should be pursued, and the information used as appropriate.

4.3 Radiation Dose Assessment Principles for J-Village Visitors

As mentioned above, individuals who visited J-Village were monitored for external radiation exposures using individual dosimeters, and for potential inhalation or ingestion of radioactive materials by IM (*in vivo*) scans or urine bioassay (*in vitro*) monitoring (Cassata et al., 2013; Hinton, 2012; USAFCRD, 2011; USAFSAM, 2011a). Therefore, doses for these individuals from the exposure pathways reflected in the results of radiological monitoring would be based on the individual's records. In this case, depending on the dosimetry records and the individual's activities, it may not be possible to separate any doses accrued at J-Village from doses received from other sources of exposure. An individual's potential doses for sources and pathways not reflected in individual monitoring results should be estimated using standard practices for retrospective dose assessments (e.g., NCRP, 2009a), and using techniques such as those developed for shore-based DOD populations during Operation Tomodachi (Cassata et al., 2012).

Based on an individual's records and personal recollection along with historical records, a scenario of participation and radiation exposure would be developed for DOD-affiliated

individuals who visited J-Village. This step is important in establishing and documenting activities of individuals in situations where they may have been exposed to radiation, and also involves producing a concise description of historical information pertaining to the radiation environment to which the individual was potentially exposed. This step also includes review and inclusion of information from the individual's statement, applicable information from historical records, a description of relevant activities, and identification of possible exposure sources and pathways.

For external doses to individuals at J-Village, applicable pathways include exposure to radiation from radionuclides in passing plume(s) and exposure to radiation from radionuclides deposited on the ground or on structures. For internal doses at J-Village, applicable exposure pathways are likely limited to inhalation of radionuclides resuspended from the ground by various mechanisms, and internal exposure from incidental ingestion of radionuclides transferred from contaminated surfaces.

Currently, limited monitoring and survey data have been located to use for the assessment of doses from inhalation or ingestion pathways for visitors to J-Village. Since activities of these individuals may have varied widely, the preferred basis for an assessment of doses from the intakes of radioactive materials are an individual's IM records (Cassata et al., 2013) and bioassay results. When IM (*in vivo*) scan and *in vitro* monitoring records are not available, appropriate cohort dosimetry and environmental monitoring data may be found in this report or other sources. These data could be used to estimate an individual's doses, together with appropriate adjustments such as for time and duration of exposure at J-Village. For example, the air sampling activity concentrations presented in Section 3.4.3 might be useful in determining the significance of the inhalation pathway as a potential source of internal dose for an individual. If data in this report are not sufficient for a specific individual's assessment, it may be necessary to research additional possible sources of relevant data, such as those from MEXT and TEPCO sources, or published literature.

For individuals whose external dosimetry records cannot be located, the dosimetry data of other persons may be appropriate for use as cohort dosimetry data. To be applicable in an individual dose assessment, cohort dosimetry data must be from individuals who participated in the same mission with activities of a similar nature. For example, if an individual indicated that they were on one of the trips discussed in Section 2.2, and that they conducted similar activities as one of the individuals on those trips, the dosimetry results discussed in Section 3.2.1 might represent acceptable cohort dosimetry. If such cohort dosimetry data cannot be found, the external gamma dose can be estimated based on exposure rate measurements from nearby monitoring stations as described in Section 3.

Section 5.

Summary and Conclusions

Data characterizing the radiological environment for J-Village during the period of Operation Tomodachi (March 12–May 11, 2011) were located and are summarized in this report. The applicable data include environmental monitoring data, personal dosimetry, and internal monitoring results. The data can be used for radiation dose assessments that may be required in the future for any individuals who visited J-Village and for whom dosimetry results are not available.

External exposure rates measured at J-Village by DOD-affiliated individuals during Operation Tomodachi ranged from 0.38–0.7 mR h^{-1} (3.8–7 μSv h^{-1}). The highest recorded external exposure rate at a nearby monitoring location for the period of time that visits to J-Village may have occurred was 0.35 mR h^{-1} (3.5 μSv h^{-1}), measured on March 25, 2011. Air, soil, and vegetation sampling results are also summarized in this report.

Available documentation indicates that a total of approximately 20 DOD-affiliated individuals visited J-Village on three dates during Operation Tomodachi. All of these trips were day visits that took place on March 24, 25, and 27, 2011. Personal external dosimetry or internal monitoring results are available for 14 of these individuals. External dosimetry data (EPD and TLD) showed that the maximum recorded dose for an individual for any visit was 0.0013 rem (0.013 mSv). *In vivo* monitoring results indicated net count rates that were less than MDA values for both thyroid and effective dose for all monitored individuals.

The data included in this report, plus the knowledge that DOD-affiliated individuals did not spend long periods of time at J-Village during Operation Tomodachi, allow for the conclusion that any external or internal doses accrued while at J-Village are likely to be relatively low (e.g., comparable to radiation doses from ubiquitous background radiation [NCRP, 2009b]).

Guidelines are provided for performing future individual radiation dose assessments for individuals who travelled to J-Village. The guidelines emphasize the collection and use of information about the individual's specific activities and all personal dosimetry records. If personal dosimetry or cohort dosimetry results are not available, the radiological data in this report provide a basis for characterizing potential doses for DOD-affiliated individuals who visited J-Village during Operation Tomodachi.

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Section 6.

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Appendix A.

AFRAT Surveillance Team Reports

This appendix contains images of the trip reports prepared by AFRAT members for the trips to J-Village on March 25 and March 27, 2011 (Figure A-1 and Figure A-2). Each report contains certain specific details concerning the trips, and also a free-form summary of the trip written by the AFRAT member. The reports have been modified only to reduce their sizes for printing and to redact the names of individuals.

AFRAT Surveillance Team

1. Event Name: OPERATION TOMODACHI	2. RSE Name: DV Support to J-Village	Date: 25 Mar 11

3. Mission Description:

Provide radiological support to DV's visiting J-Village.

4. Surveillance Team:

Lead [redacted] Member

Member Member

5. Logistical Information:

Show Time	1030 hrs	Arrival Time / Location	J-Village
Departure Time	1300 hrs	Arrival POC / Phone #	
Departure Location	PDF Hangar	Number of People at Location	
Estimated Return Time	1700 hrs	Departure Date / Time	

6. Contact #'s (AFRAT satellite phones 881676340730 & 0731):

AFRAT TOC 225-4645 AFRAT Surveillance 225-5706

7. Work Assignment:

- **Stay on aircraft**
- **Collect exposure rates**
- **Advise aircrew if mission limits of 1 rem/hr or 5 rem total are jeopardized**
- **Collect air sample with DOE low flow air sampler**
- **Conduct contamination survey of DVs with Bicron PGM upon their return to the aircraft**
- **Provide summary upon return to Yokota AB (accomplishments and lessons learned; use back of form – if needed)**

8. Special Instructions / PPE:

- Inventory all items for RSE mission
- Determine PPE requirements
- Visit AFRAT TOC before heading out and check back in upon return (provide debrief)

Prepared By: [redacted] Approved By: [redacted]

9. Results/Findings:

- Number of Samples Collected:

Air: 1	Soil: 0	Vegetation: 0	Water: 0	Swipes: 0	Misc:

- Amount of PPE Used:

Tyvek Suits: 0	Nitrile Gloves (pair): 2	Booties (pair): 0	Resp. Cartridges (pair): 0	N-95 Respirators: 0	Misc:

- Dosimetry Information:

# of Personnel on Mission: 9	# of Personnel without EPDs: 0	# of EPDs issued: 8	# of Personnel Trained: 8

- Total Mission Dose for AFRAT Surveillance Personnel from EPD:

Rank Last Name	Estimated Time in Zone (specify warm vs hot)	Beta Dose (mRem)	Gamma Dose (mRem)
[redacted]	1 hr 30 mins in hot zone	0.82	0.62

- Mission in Support of:

BJOCC	# of Personnel Supported: 9	# of Personnel Trained: 0	Training Type: N/A

- Summary of Mission:

Provided radiological support to 5 DV's (including [redacted], USN and [redacted], USMC) and 3 flight crew visiting J-Village. While on ground, collected dose rate measurements using a Victoreen 451P ionization chamber both inside and outside the aircraft. Conducted ground surveillance outside aircraft door using a Bicron PGM probe. A background reading for the Bicron PGM was also established inside the aircraft. An air sample was collected over a 1 hr 15 min period utilizing a low flow air pump on loan from the DOE. GPS coordinates were obtained from the air crew as the Trimble GPS could not obtain satellite lock from inside the helicopter. Upon return of DV's to the helicopter, each PAX was scanned for contamination using the Bicron PGM. The soles and sides of shoes/boots were scanned as well as the pants legs around the ankles. No DVs exceeded 2 times background. J-Village is located in a sports complex (20 kilometers from ground zero). The helicopter landing zone is the astro-turf soccer field. Vehicle staging area is in an adjacent soccer field. It was noted that local Japanese in the area were wearing PPE to include protective suits, boot covers and a variety of respiratory protection ranging from surgical masks to respirators. The air sample was turned over to DOE for expedient processing with follow-on processing by the AFRAT laboratory. Highest dose rate was 0.46 mR/hr.

Figure A-1. AFRAT surveillance team report for March 25, 2011

AFRAT Surveillance Team

1. Event Name: OPERATION TOMODACHI	2. RSE Name: DV Support to J-Village	Date: 27 Mar 11

3. Mission Description:

Provide radiological support to DV's visiting J-Village.

4. Surveillance Team:

Lead	[redacted]	Member	
Member		Member	

5. Logistical Information:

Show Time	0800 hrs	Arrival Time / Location	1000 hrs / J-Village
Departure Time	0840 hrs	Arrival POC / Phone #	
Departure Location	PDF Hangar	Number of People at Location	
Estimated Return Time	1500 hrs	Departure Date / Time	27 Mar 11 / 1330 hrs

6. Contact #'s (AFRAT satellite phones 881676340730 & 0731):

AFRAT TOC	225-4645	AFRAT Surveillance	225-5706

7. Work Assignment:

- **Stay close to aircraft**
- **Collect exposure rates**
- **Collect soil, water, vegetation & swipe samples (if appropriate)**
- **Document all sample locations with GPS coordinates**
- **Provide summary upon return (accomplishments and lessons learned; use back of form – if needed)**

8. Special Instructions / PPE:

- Inventory all items for RSE mission
- Determine PPE requirements
- Visit AFRAT TOC before heading out and check back in upon return (provide debrief)

Prepared By: [redacted]	Approved By: [redacted]

9. Results/Findings:

- Number of Samples Collected:

Air: 0	Soil: 2	Vegetation: 3	Water: 0	Swipes: 0	Misc:

- Amount of PPE Used:

Tyvek Suits: 0	Nitrile Gloves (pair): 15	Booties (pair): 15	Resp. Cartridges (pair): 0	N-95 Respirators: 0	Misc: Sample bags

- Dosimetry Information:

# of Personnel on Mission: 10	# of Personnel without EPDs: 0	# of EPDs issued: 9	# of Personnel Trained: 9

- Total Mission Dose for AFRAT Surveillance Personnel from EPD:

Rank Last Name	Estimated Time in Zone (specify warm vs hot)	Beta Dose (mRem)	Gamma Dose (mRem)
[redacted]	4 hrs in hot zone	1.8	0.89

- Mission in Support of:

BJOCC	# of Personnel Supported: 9	# of Personnel Trained: 0	Training Type: N/A

- Summary of Mission:

Provided radiological support to 6 DV's (including [redacted], USN) and 3 flight crew visiting J-Village. While on ground, collected soil and vegetation samples (annotated GPS coordinates). Vegetation sample #1 consisted of moss and grass and was collected on a slope next to the soccer field (West side of field). Soil sample #1 collected next to soccer field (West side of field). The top soil had little vegetation growing on it. Vegetation sample # 2 consisted of leaves from a small tree next to the soccer field (West side of field). Vegetation sample # 3 consisted of tall grass in NE corner of soccer field. Soil sample #2 consisted of loose dirt (no vegetation) from the NE corner of the soccer field. J-Village is located in a sports complex (20 kilometers from ground zero). The helicopter landing zone is the astro-turf soccer field. Vehicle staging area is in an adjacent soccer field. All samples have been turned into the AFRAT laboratory. Highest dose rate was 0.7 mR/hr.

Figure A-2. AFRAT surveillance team report for March 27, 2011

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Appendix B.

Latitude/longitude Locations of Environmental Measurements and Samples

This Appendix contains a table of latitude and longitude coordinate specifications for locations on or near J-Village where environmental measurements and/or samples were taken (Table B-1). Each of the locations and the type(s) of measurement or sample taken is described in the main report. The decimal coordinates in Table B-1 are used in the text of the main report; specifications in degree-minute-second format are provided here for ease of use where this format is required. Conversions between decimal format and degree-minute-second format were accomplished using the converter provided by FCC (2012).

Table B-1. Latitude/longitude locations of samples/surveys

Measurement/Sample*	Latitude, Longitude	
	Decimal Location	Degree-minute-second Location
MEXT dose rate monitoring location near J-Village	37.241536 , 141.005831	37° 14′ 29.5″ , 141° 0′ 21.0″
Background radiation site south of J-Village	37.23375 , 141.00157	37° 14′ 1.5″ , 141° 0′ 5.6″
Background radiation site northwest of J-Village	37.258163 , 140.9966	37° 15′ 29.4″ , 140° 59′ 47.8″
March 25 AFRAT exposure rate measurements	37.2455 , 141.0045	37° 14′ 43.8″ , 141° 0′ 16.2″
March 25 AFRAT air Sample 20079		
March 25 AFRAT air Sample 20080		
March 27 AFRAT soil Sample 20196	37.245173 , 141.00428	37° 14′ 42.62″ , 141° 0′ 15.41″
March 27 AFRAT vegetation Sample 20387†		
March 27 AFRAT soil sample point 1	37.245173 , 141.00428	37° 14′ 42.62″ , 141° 0′ 15.41″
March 27 AFRAT vegetation sample point 2	37.245161 , 141.00447	37° 14′ 42.58″ , 141° 0′ 16.09″
March 27 AFRAT soil sample point 3	37.246067 , 141.004009	37° 14′ 45.84″ , 141° 0′ 14.43″
March 27 AFRAT vegetation sample point 4	37.246105 , 141.003961	37° 14′ 45.98″ , 141° 0′ 14.26″
March 27 AFRAT vegetation sample point 5	37.245089 , 141.004517	37° 14′ 42.32″ , 141° 0′ 16.26″

*All dates are 2011.

†Assumed to be the same location as soil Sample 20196 (see Section 3).

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Appendix C.

External Radiation Monitoring Data for Location Nearest to J-Village

This appendix contains a listing of the external environmental monitoring readings obtained at the monitoring location that is closest to J-Village. As shown in Figure 2 in the main body of this report, this site is approximately 0.5 km (0.3 mi) south of the J-Village main building entrance, near the southeast corner of the complex. The external measurements presented here were taken at the monitoring site near J-Village by TEPCO or other entities (e.g., Kyushu Electric Power Company) and were reported as equivalent dose rates ($\mu Sv\ h^{-1}$). The measurement data were collected and made available by MEXT (MEXT, 2013). The MEXT data were obtained by the U.S. National Nuclear Security Administration (NNSA), which compiled them into a single user-friendly data set within their Japan Response Data Repository (NNSA, 2012). The measurement data presented in Table C-1 were obtained from the NNSA repository (NNSA, 2012) and have been spot-checked against the MEXT data to ensure accuracy of transcription. The monitoring site is described in MEXT reports as 20 km (12.5 mi) south of FDNPS at latitude 37.241536 and longitude 141.005831. MEXT reports also sometimes refer to the location as "Futaba county Naraha town Yamadaoka Utsukushimori" (MEXT, 2013). NNSA describes the site as "12.5 miles south of FDNPS, bearing 186°." NNSA also describes the measurements as from a "fixed" location (i.e., collected using stationary detection equipment). However, some of the measurements were collected using an ionization chamber survey meter, although later measurements at this location were measured using a thallium-activated, sodium-iodide scintillation detector (MEXT, 2013).

Table C-1. Monitoring data for location nearest to J-Village (Source: MEXT/NNSA)

NNSA ID	Measurement Date/Time		Measurement as Reported by NNSA (mR h^{-1})	Converted Measurement (µSv h^{-1})
	Pacific Daylight	Japan Standard		
162609	3/16/11 20:12	3/17/11 12:12	0.45	4.5
162607	3/17/11 0:20	3/17/11 16:20	0.47	4.7
162739	3/17/11 18:41	3/18/11 10:41	0.4	4
162741	3/17/11 22:25	3/18/11 14:25	0.46	4.6
162891	3/18/11 19:15	3/19/11 11:15	0.26	2.6
162893	3/18/11 23:00	3/19/11 15:00	0.26	2.6
155579	3/19/11 18:25	3/20/11 10:25	0.23	2.3
155577	3/19/11 23:00	3/20/11 15:00	0.23	2.3
162985	3/20/11 18:50	3/21/11 10:50	0.29	2.9
162987	3/20/11 22:40	3/21/11 14:40	1.2	12
163669	3/21/11 19:40	3/22/11 11:40	0.39	3.9
164511	3/22/11 18:00	3/23/11 10:00	0.42	4.2
165093	3/23/11 18:35	3/24/11 10:35	0.31	3.1
165091	3/23/11 22:00	3/24/11 14:00	0.32	3.2
171407	3/24/11 18:15	3/25/11 10:15	0.35	3.5
171405	3/24/11 21:15	3/25/11 13:15	0.29	2.9
177077	3/26/11 21:33	3/27/11 13:33	0.28	2.8
177757	3/27/11 18:48	3/28/11 10:48	0.25	2.5
177755	3/27/11 21:53	3/28/11 13:53	0.25	2.5
180121	3/28/11 18:30	3/29/11 10:30	0.25	2.5
180119	3/28/11 21:38	3/29/11 13:38	0.23	2.3
267963	3/30/11 21:36	3/31/11 13:36	0.22	2.2
324407	3/31/11 18:57	4/1/11 10:57	0.22	2.2
324405	3/31/11 22:18	4/1/11 14:18	0.19	1.9
332527	4/1/11 18:42	4/2/11 10:42	0.19	1.9
332525	4/1/11 21:54	4/2/11 13:54	0.19	1.9
355535	4/2/11 18:40	4/3/11 10:40	0.19	1.9
355533	4/2/11 21:52	4/3/11 13:52	0.17	1.7
362931	4/3/11 18:18	4/4/11 10:18	0.17	1.7
362929	4/3/11 21:42	4/4/11 13:42	0.17	1.7

NNSA ID	Measurement Date/Time		Measurement as Reported by NNSA (mR h^{-1})	Converted Measurement (µSv h^{-1})
	Pacific Daylight	Japan Standard		
378461	4/4/11 17:59	4/5/11 9:59	0.16	1.6
378459	4/4/11 21:00	4/5/11 13:00	0.15	1.5
396165	4/5/11 18:09	4/6/11 10:09	0.22	2.2
398681	4/5/11 18:09	4/6/11 10:09	0.22	2.2
396163	4/5/11 21:11	4/6/11 13:11	0.15	1.5
398679	4/5/11 21:11	4/6/11 13:11	0.15	1.5
398795	4/6/11 18:02	4/7/11 10:02	0.13	1.3
398793	4/6/11 21:09	4/7/11 13:09	0.15	1.5
416851	4/7/11 17:59	4/8/11 9:59	0.13	1.3
416849	4/7/11 20:59	4/8/11 12:59	0.13	1.3
429425	4/8/11 18:07	4/9/11 10:07	0.12	1.2
429423	4/8/11 21:07	4/9/11 13:07	0.11	1.1
431725	4/9/11 18:08	4/10/11 10:08	0.12	1.2
431723	4/9/11 21:25	4/10/11 13:25	0.11	1.1
447571	4/10/11 18:06	4/11/11 10:06	0.11	1.1
447569	4/10/11 21:21	4/11/11 13:21	0.11	1.1
451399	4/11/11 18:27	4/12/11 10:27	0.1	1
451397	4/11/11 21:28	4/12/11 13:28	0.1	1
470005	4/12/11 18:00	4/13/11 10:00	0.1	1
470003	4/12/11 21:00	4/13/11 13:00	0.1	1
478143	4/13/11 17:49	4/14/11 9:49	0.1	1
478141	4/13/11 21:11	4/14/11 13:11	0.1	1
485805	4/14/11 18:03	4/15/11 10:03	0.1	1
485803	4/14/11 21:14	4/15/11 13:14	0.1	1
490671	4/15/11 18:00	4/16/11 10:00	0.1	1
490669	4/15/11 21:31	4/16/11 13:31	0.1	1
492287	4/16/11 17:40	4/17/11 9:40	0.09	0.9
492285	4/16/11 20:45	4/17/11 12:45	0.09	0.9
524349	4/18/11 17:44	4/19/11 9:44	0.08	0.8
524347	4/18/11 21:51	4/19/11 13:51	0.08	0.8
546421	4/20/11 17:38	4/21/11 9:38	0.08	0.8
553647	4/20/11 17:54	4/21/11 9:54	0.09	0.9

NNSA ID	Measurement Date/Time		Measurement as Reported by NNSA (mR h^{-1})	Converted Measurement (µSv h^{-1})
	Pacific Daylight	Japan Standard		
546419	4/20/11 20:56	4/21/11 12:56	0.08	0.8
553645	4/20/11 21:27	4/21/11 13:27	0.08	0.8
553775	4/21/11 17:51	4/22/11 9:51	0.07	0.7
553773	4/21/11 21:31	4/22/11 13:31	0.08	0.8
562249	4/22/11 17:42	4/23/11 9:42	0.08	0.8
562247	4/22/11 21:05	4/23/11 13:05	0.08	0.8
567689	4/23/11 17:34	4/24/11 9:34	0.07	0.7
567687	4/23/11 21:01	4/24/11 13:01	0.08	0.8
573931	4/24/11 18:18	4/25/11 10:18	0.07	0.7
573929	4/24/11 21:18	4/25/11 13:18	0.07	0.7
580271	4/25/11 18:11	4/26/11 10:11	0.07	0.7
580269	4/25/11 21:22	4/26/11 13:22	0.07	0.7
585331	4/26/11 17:59	4/27/11 9:59	0.07	0.7
585329	4/26/11 21:13	4/27/11 13:13	0.07	0.7
593417	4/27/11 17:51	4/28/11 9:51	0.07	0.7
593415	4/27/11 21:06	4/28/11 13:06	0.07	0.7
599765	4/28/11 18:04	4/29/11 10:04	0.07	0.7
599763	4/28/11 21:17	4/29/11 13:17	0.07	0.7
614729	4/29/11 17:36	4/30/11 9:36	0.07	0.7
614727	4/29/11 20:50	4/30/11 12:50	0.07	0.7
614667	4/30/11 18:08	5/1/11 10:08	0.07	0.7
614665	4/30/11 21:22	5/1/11 13:22	0.07	0.7
646871	5/1/11 17:31	5/2/11 9:31	0.07	0.7
646869	5/1/11 21:23	5/2/11 13:23	0.07	0.7
652009	5/2/11 17:26	5/3/11 9:26	0.07	0.7
652007	5/2/11 21:08	5/3/11 13:08	0.07	0.7
662747	5/3/11 17:56	5/4/11 9:56	0.06	0.6
662745	5/3/11 21:12	5/4/11 13:12	0.06	0.6
668605	5/4/11 17:36	5/5/11 9:36	0.07	0.7
668603	5/4/11 21:07	5/5/11 13:07	0.06	0.6
676679	5/5/11 17:36	5/6/11 9:36	0.06	0.6
676677	5/5/11 21:02	5/6/11 13:02	0.06	0.6

NNSA ID	Measurement Date/Time		Measurement as Reported by NNSA (mR h^{-1})	Converted Measurement (µSv h^{-1})
	Pacific Daylight	Japan Standard		
680295	5/6/11 17:23	5/7/11 9:23	0.07	0.7
680293	5/6/11 21:01	5/7/11 13:01	0.06	0.6
714801	5/9/11 17:40	5/10/11 9:40	0.06	0.6
714799	5/9/11 21:05	5/10/11 13:05	0.06	0.6
726039	5/10/11 17:00	5/11/11 9:00	0.06	0.6
726037	5/10/11 20:35	5/11/11 12:35	0.06	0.6
726597	5/11/11 17:10	5/12/11 9:10	0.06	0.6
726595	5/11/11 20:32	5/12/11 12:32	0.06	0.6
750897	5/13/11 17:09	5/14/11 9:09	0.059	0.59
764791	5/13/11 17:09	5/14/11 9:09	0.059	0.59
733377	5/13/11 17:10	5/14/11 9:10	0.05	0.5
740097	5/13/11 17:10	5/14/11 9:10	0.05	0.5
733375	5/13/11 20:30	5/14/11 12:30	0.05	0.5
740095	5/13/11 20:30	5/14/11 12:30	0.05	0.5
750875	5/13/11 20:37	5/14/11 12:37	0.056	0.56
764769	5/13/11 20:37	5/14/11 12:37	0.056	0.56
755917	5/14/11 17:10	5/15/11 9:10	0.06	0.6
755915	5/14/11 20:10	5/15/11 12:10	0.06	0.6
750543	5/15/11 17:27	5/16/11 9:27	0.06	0.6
750541	5/15/11 20:27	5/16/11 12:27	0.05	0.5
750919	5/16/11 17:14	5/17/11 9:14	0.056	0.56
750917	5/16/11 20:13	5/17/11 12:13	0.056	0.56
761831	5/17/11 17:23	5/18/11 9:23	0.057	0.57
761829	5/17/11 20:26	5/18/11 12:26	0.055	0.55
770171	5/18/11 17:20	5/19/11 9:20	0.06	0.6
770169	5/18/11 20:22	5/19/11 12:22	0.06	0.6
786745	5/19/11 17:06	5/20/11 9:06	0.053	0.53
786743	5/19/11 20:08	5/20/11 12:08	0.054	0.54
786899	5/20/11 17:14	5/21/11 9:14	0.054	0.54
786897	5/20/11 20:09	5/21/11 12:09	0.058	0.58
787059	5/21/11 17:12	5/22/11 9:12	0.052	0.52
787057	5/21/11 20:20	5/22/11 12:20	0.057	0.57

NNSA ID	Measurement Date/Time		Measurement as Reported by NNSA (mR h^{-1})	Converted Measurement (µSv h^{-1})
	Pacific Daylight	Japan Standard		
791199	5/22/11 17:25	5/23/11 9:25	0.053	0.53
791197	5/22/11 20:30	5/23/11 12:30	0.053	0.53
797931	5/23/11 17:19	5/24/11 9:19	0.054	0.54
797929	5/23/11 20:35	5/24/11 12:35	0.053	0.53
797927	5/24/11 17:33	5/25/11 9:33	0.053	0.53
797925	5/24/11 20:35	5/25/11 12:35	0.052	0.52
808061	5/25/11 17:13	5/26/11 9:13	0.054	0.54
808059	5/25/11 20:18	5/26/11 12:18	0.051	0.51
808181	5/26/11 17:08	5/27/11 9:08	0.054	0.54
808179	5/26/11 20:25	5/27/11 12:25	0.056	0.56
824413	5/28/11 17:07	5/29/11 9:07	0.05	0.5
824411	5/28/11 20:22	5/29/11 12:22	0.05	0.5
829833	5/29/11 17:44	5/30/11 9:44	0.05	0.5
829831	5/29/11 20:50	5/30/11 12:50	0.05	0.5
836571	5/30/11 17:37	5/31/11 9:37	0.05	0.5
836569	5/30/11 20:40	5/31/11 12:40	0.05	0.5
837913	5/31/11 17:21	6/1/11 9:21	0.05	0.5
837911	5/31/11 20:26	6/1/11 12:26	0.05	0.5

Abbreviations, Acronyms, and Unit Symbols

AFRAT	Air Force Radiation Assessment Team
Bq	becquerel
CDR	Commander
Ci	curie
CMAT	Consequence Management Advisory Team
DARWG	Dose Assessment and Recording Working Group
DOD	Department of Defense
DTRA	Defense Threat Reduction Agency
DV	distinguished visitor
EPD	electronic personal dosimeter
FDNPS	Fukushima Daiichi Nuclear Power Station
FRAGO	fragmentary order
g	gram
GOJ	Government of Japan
h	hour
IAEA	International Atomic Energy Agency
ID	identification
IM	internal monitoring
JSDF	Japanese Self-Defense Forces
JSFJ	Joint Support Forces-Japan
JST	Japan Standard Time
km	kilometer
L	liter
LNO	liaison office
MDA	minimum detectable activity
MEXT	Ministry of Education, Culture, Sports, Science & Technology
µSv	microsievert
mi	mile
mR	milliroentgen
mrem	millirem
mSv	millisievert
NCRP	National Council on Radiation Protection and Measurements

NNSA	National Nuclear Security Administration
pCi	picocurie
PGM	Pancake Geiger-Müller
POC	point of contact
SI	International System
TEPCO	Tokyo Electric Power Company
TLD	thermoluminescent dosimeter
TSgt	Technical Sergeant
U.S.	United States
USAF	United States Air Force
USAFCRD	United States Air Force Center for Radiation Dosimetry
USAFSAM	United States Air Force School of Aerospace Medicine
USFJ	United States Forces, Japan
USPACOM	United States Pacific Command
UTC	Coordinated Universal Time
WHO	World Health Organization
Z	Zulu time

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